ACE-Asia and Terra & Aqua/EOS: A 2000+ Field Campaigns on Asian Dust and Pollution Aerosol

Si-Chee Tsay

and

MODIS Atmosphere Group ***(Nov. 1999)***

NASA Goddard Space Flight Center

Greenbelt, MD, USA

Observational and Numerical Studies of Dust Storm & Regional Climate during ACE-Asia

Si-Chee Tsay and SMART/MODIS Groups

NASA Goddard Space Flight Center

Christina Hsu and Robert Curran

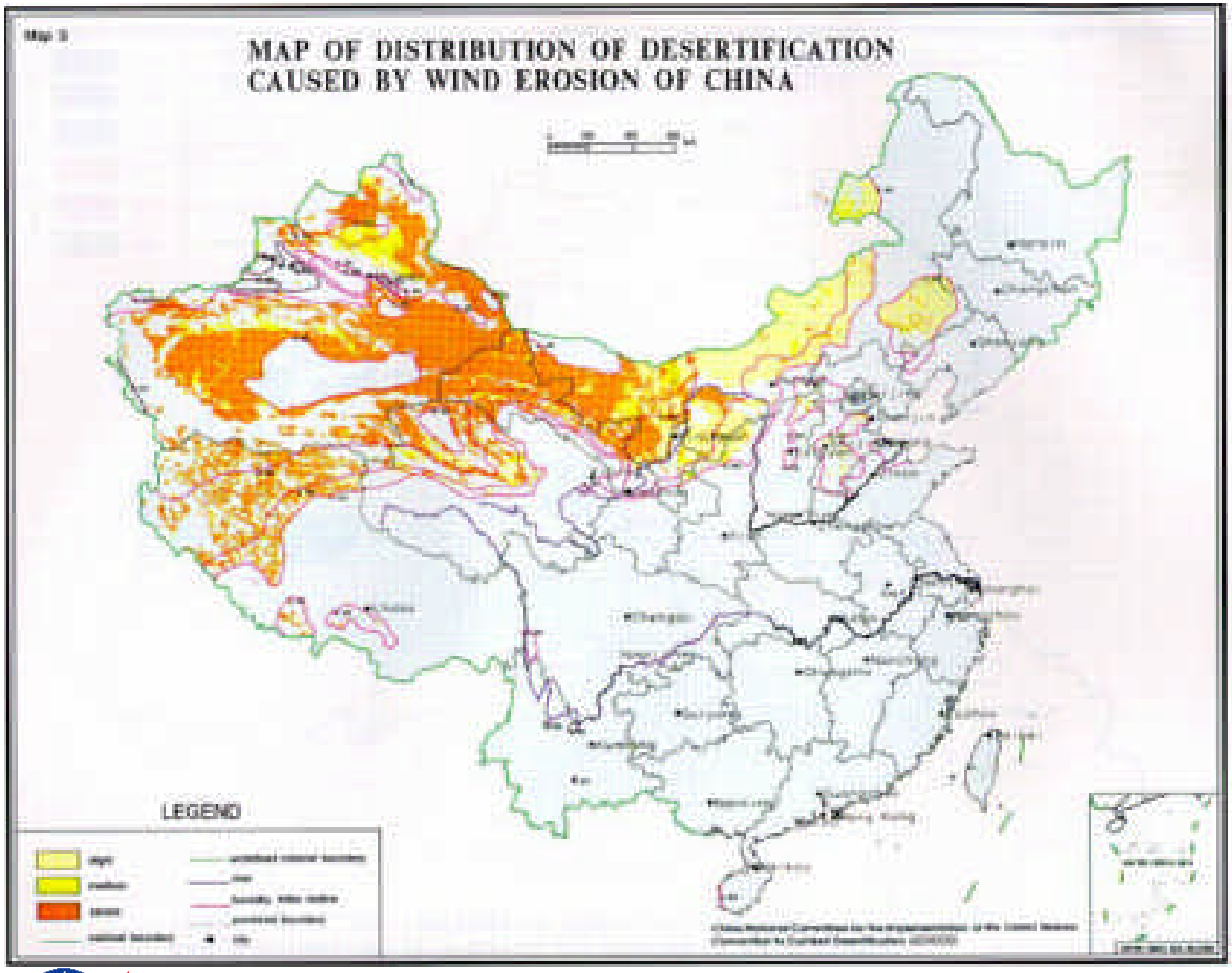
University of Maryland at Baltimore County

and

Wen-Yih Sun

Purdue University

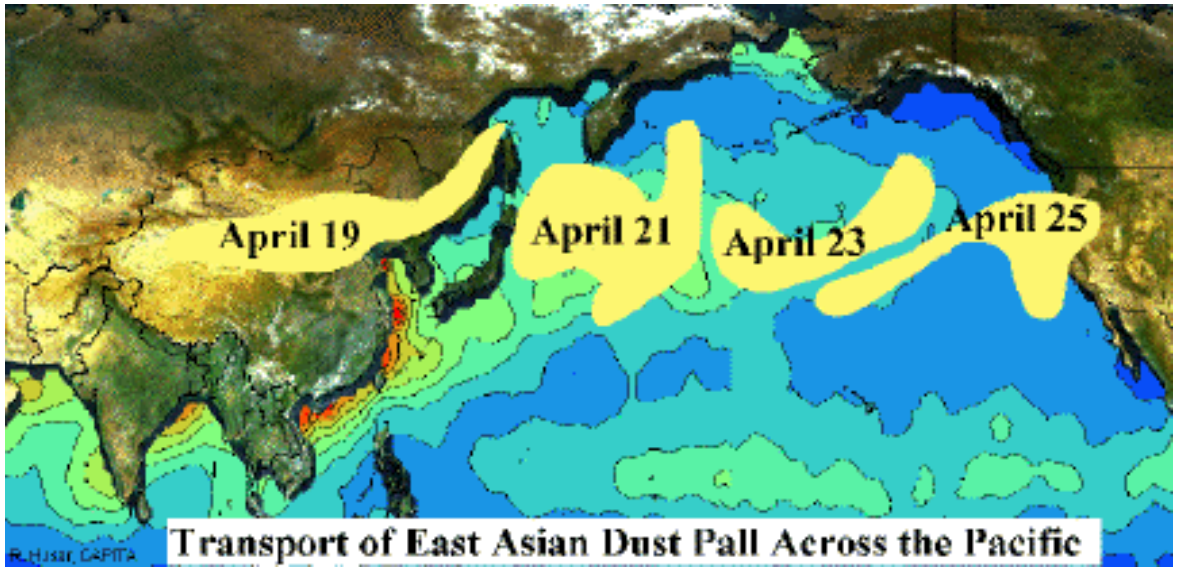
The Sky Is Falling ...



- *>40% world population reside in Asia*
- *>21% (>1.3 B) in China alone*
- *Depending on ~7% farmland*
- *2.6×10^6 km^2 (~27%)* area desertified; or 2460 km^2/year*

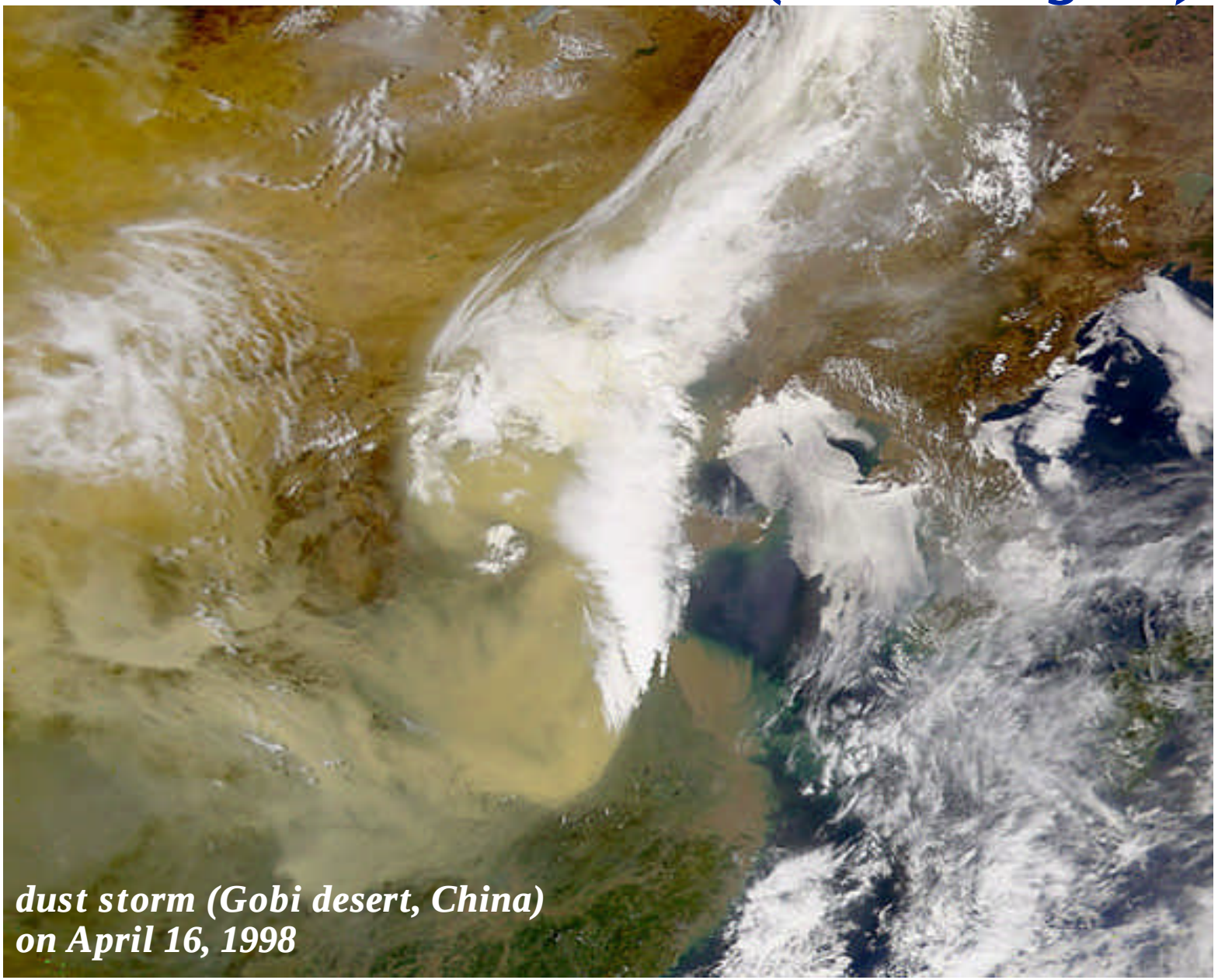
**Studley 1999*

Kosa: 1998 Events



Starting on 15 April 1998, a fierce dust storm (left) originated in the Northwest swept through China, downing electrical wires, sparking forest fires and leaving at least 12 people missing (after CNN), and (right) time series of aerosol transport across the Pacific Ocean, using AVHRR data (after Husar *et al.* 2000).

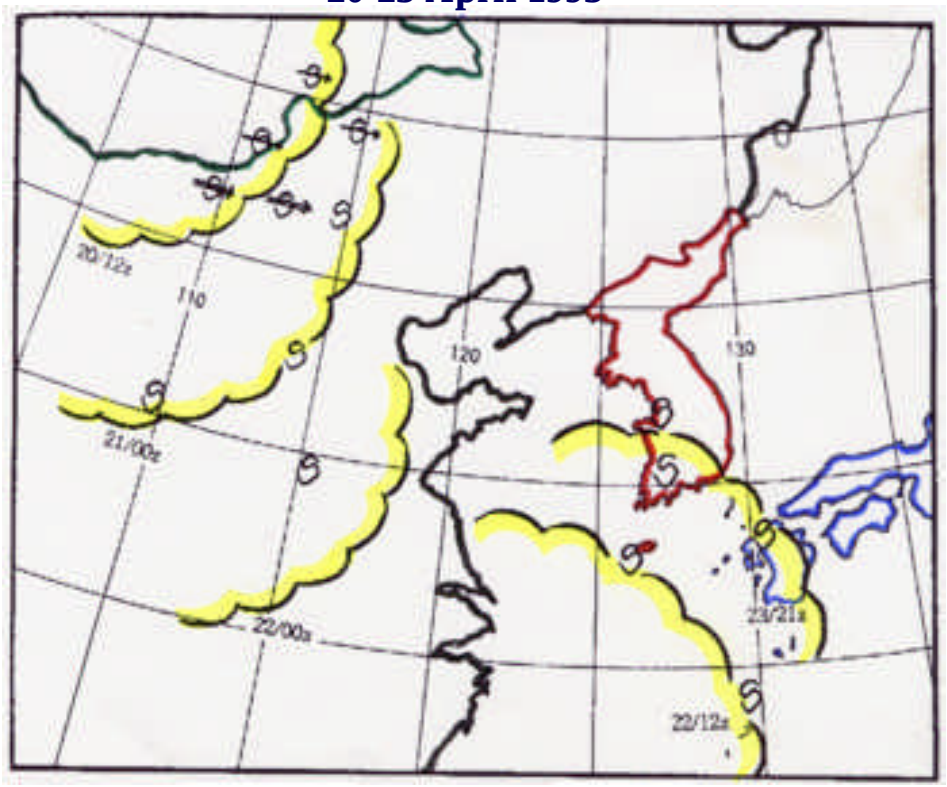
SeaWiFS: Kosa outbreak (source region)



dust storm (Gobi desert, China)
on April 16, 1998

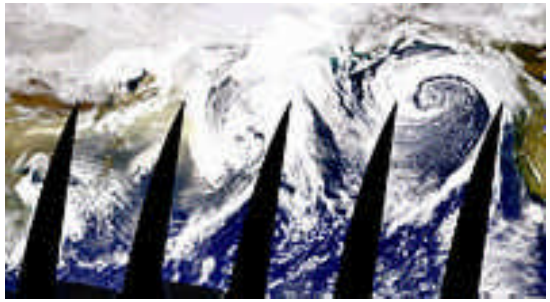
Kosa Pathway

20-23 April 1993

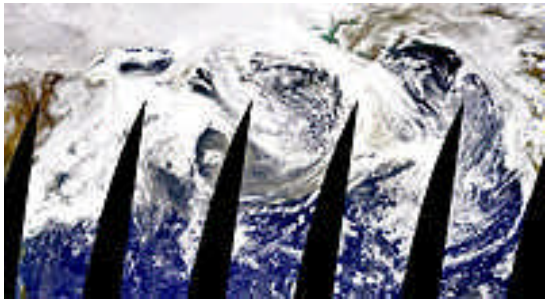


Chung and Yoon, 1996, *Atmos. Environ.*, 30, 2387-2397.

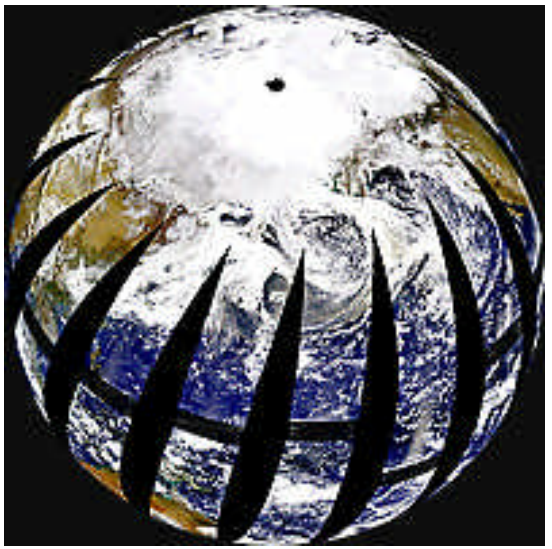
SeaWiFS: Kosa outbreak (time evolution)

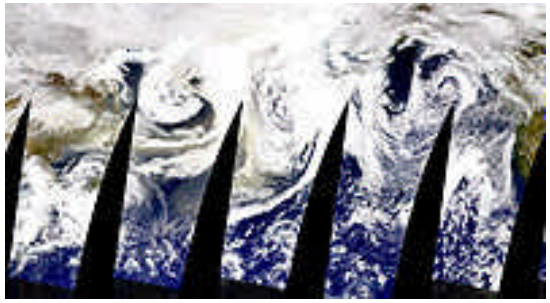


April 20, 1998



April 23, 1998





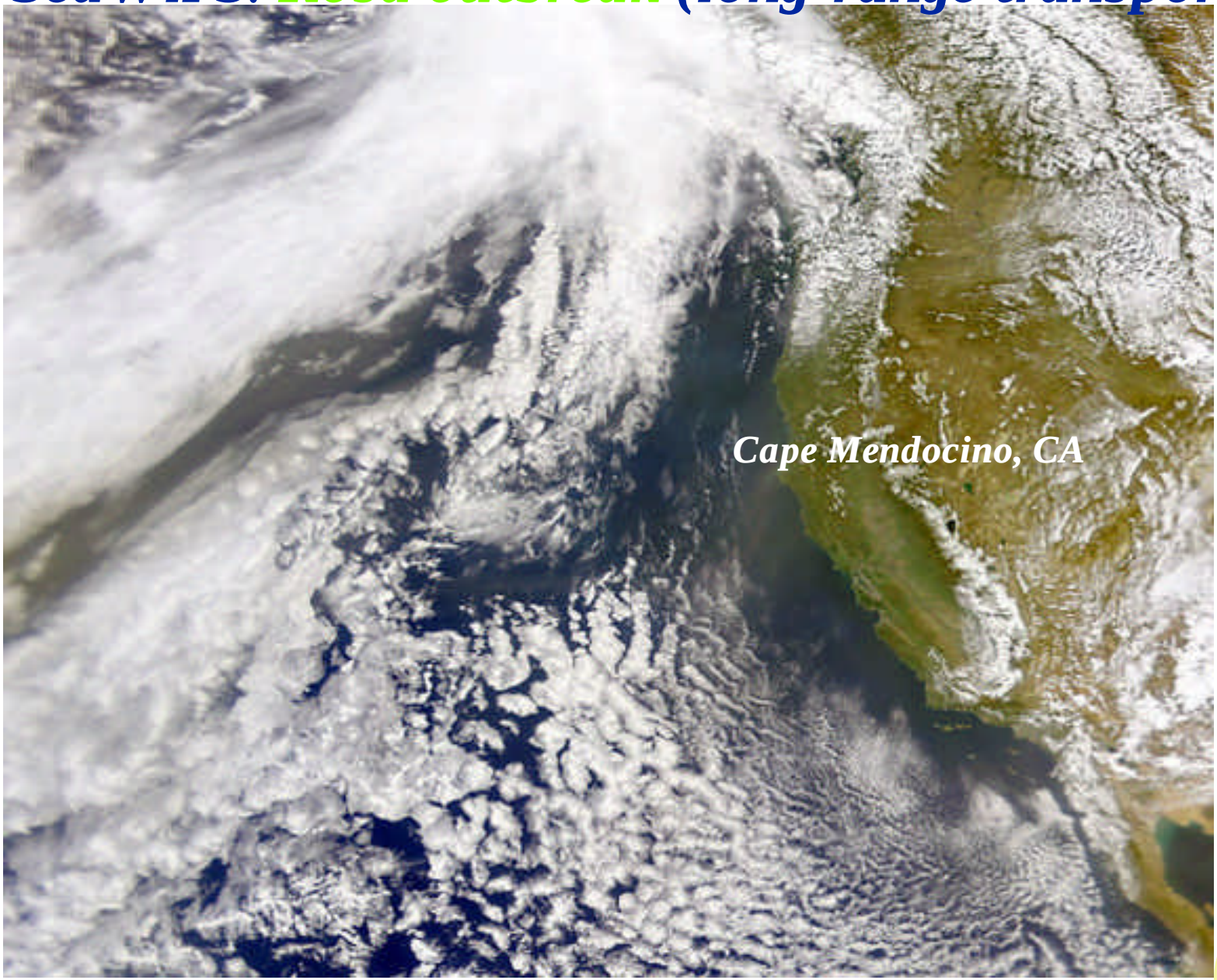
April 21, 1998

April 24, 1998

April 22, 1998

Dust storms can transport effectively a vital nutrient source (e.g., iron) for both oceans (e.g., primary productivity of plankton) and terrestrial ecosystems (e.g., rain forest)

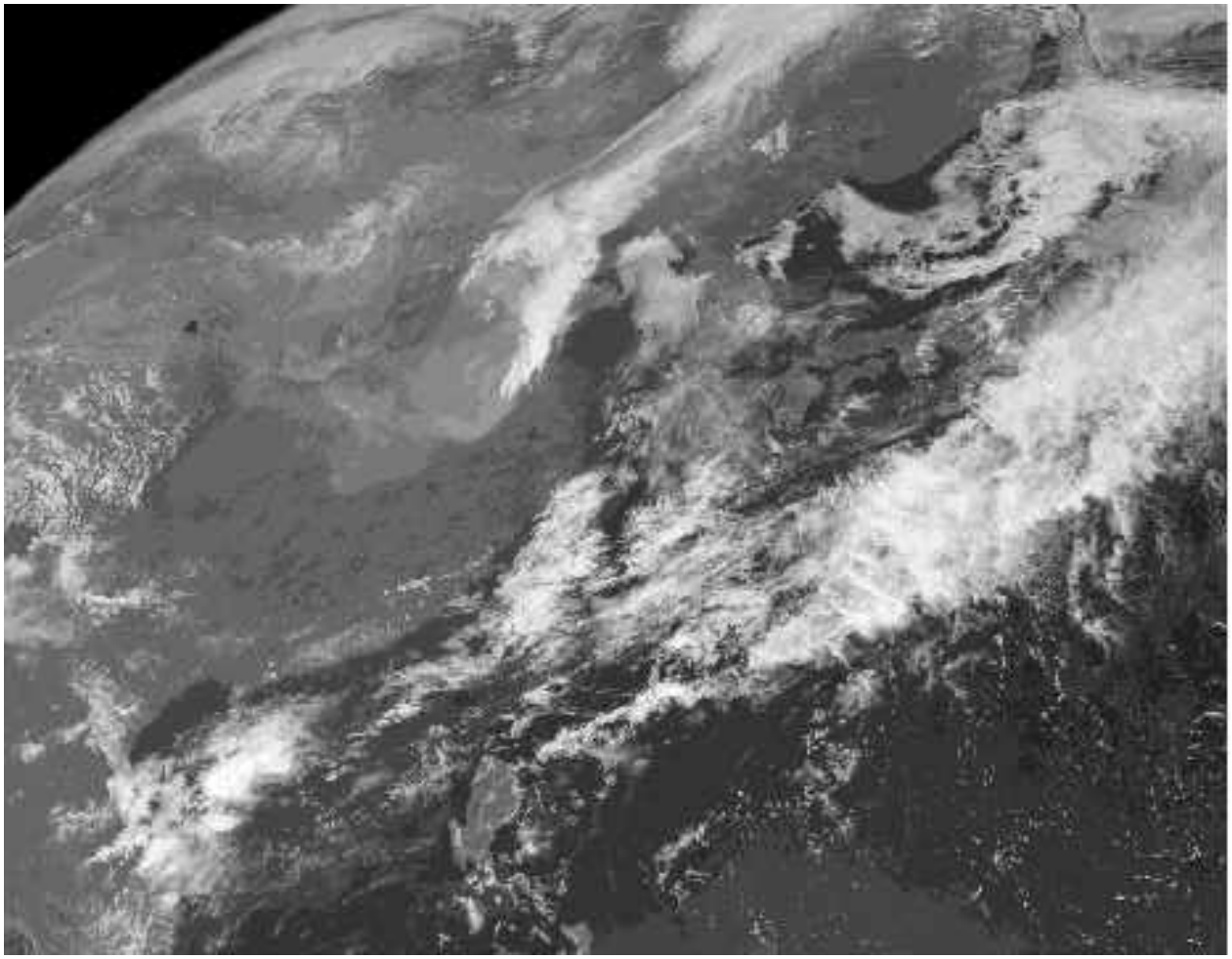
SeaWiFS: Kosa outbreak (long-range transport)



dust storm (Gobi desert, China) on April 25, 1998

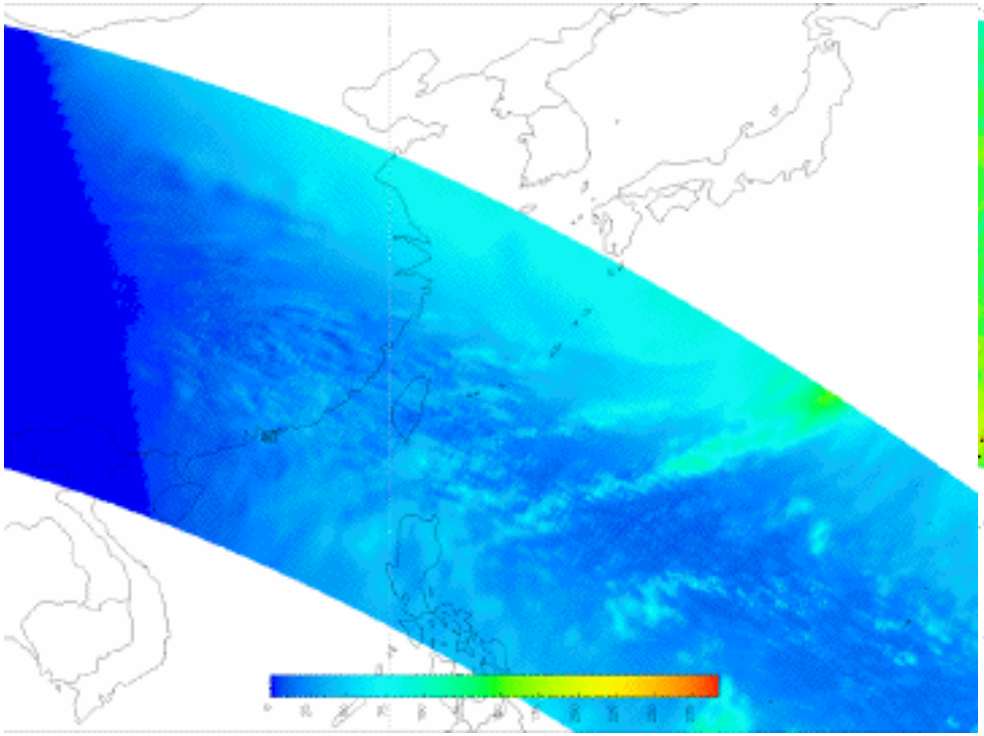
Japan/GMS-5: Kosa outbreak

dust storm (Gobi desert, China) on April 16, 1998

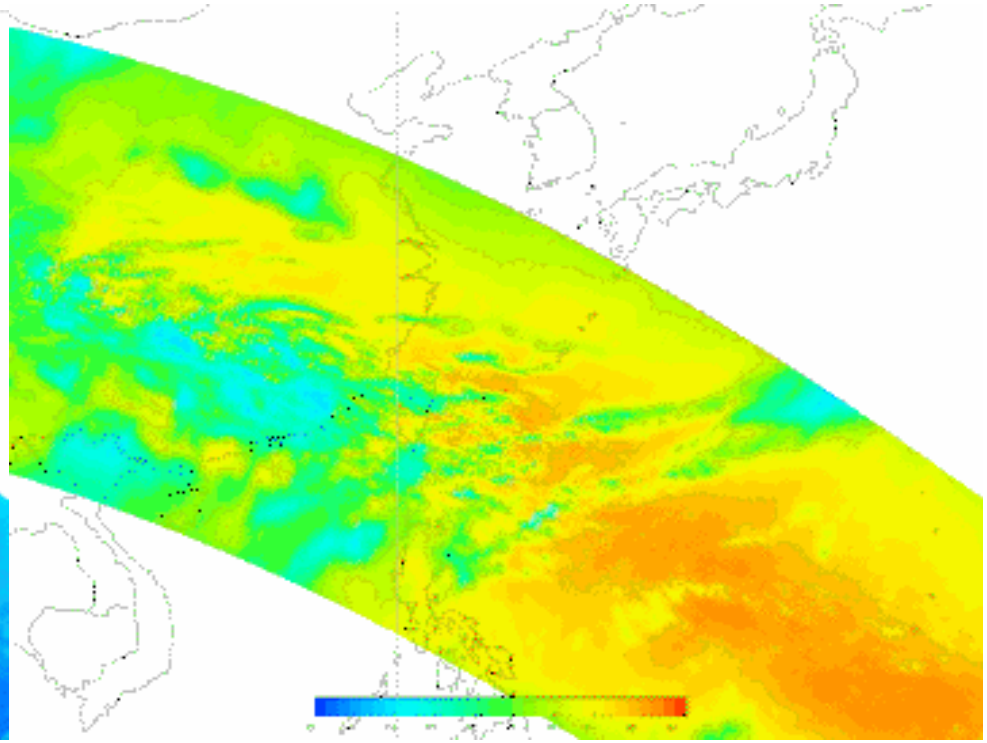


TRMM/CERES: Kosa outbreak

dust storm (Gobi desert, China) on April 18, 1998

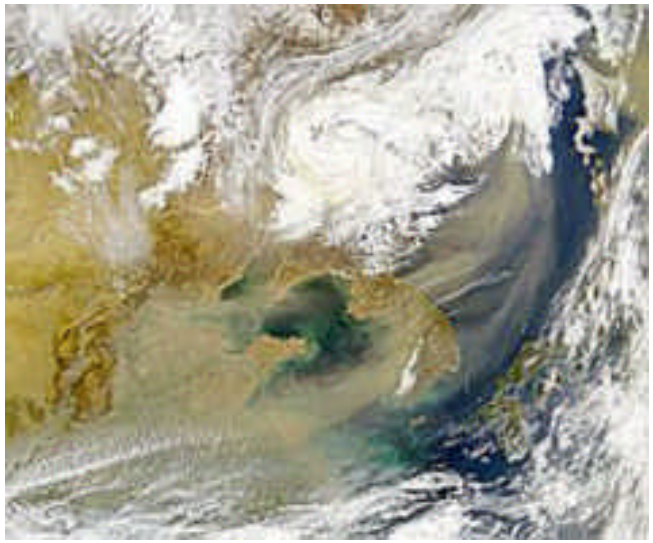


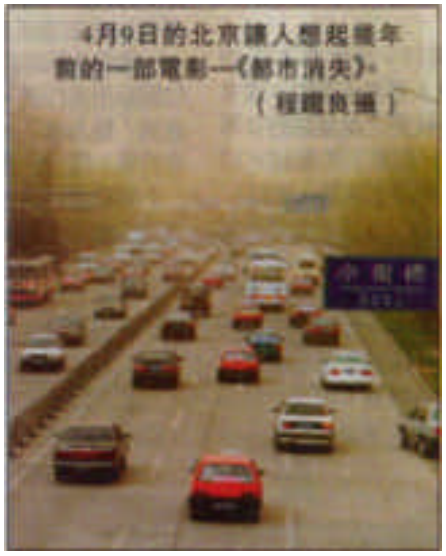
Reflected Solar Radiance (W m^{-2} sr^{-1})



Emitted Thermal Radiance (W m^{-2} sr^{-1})

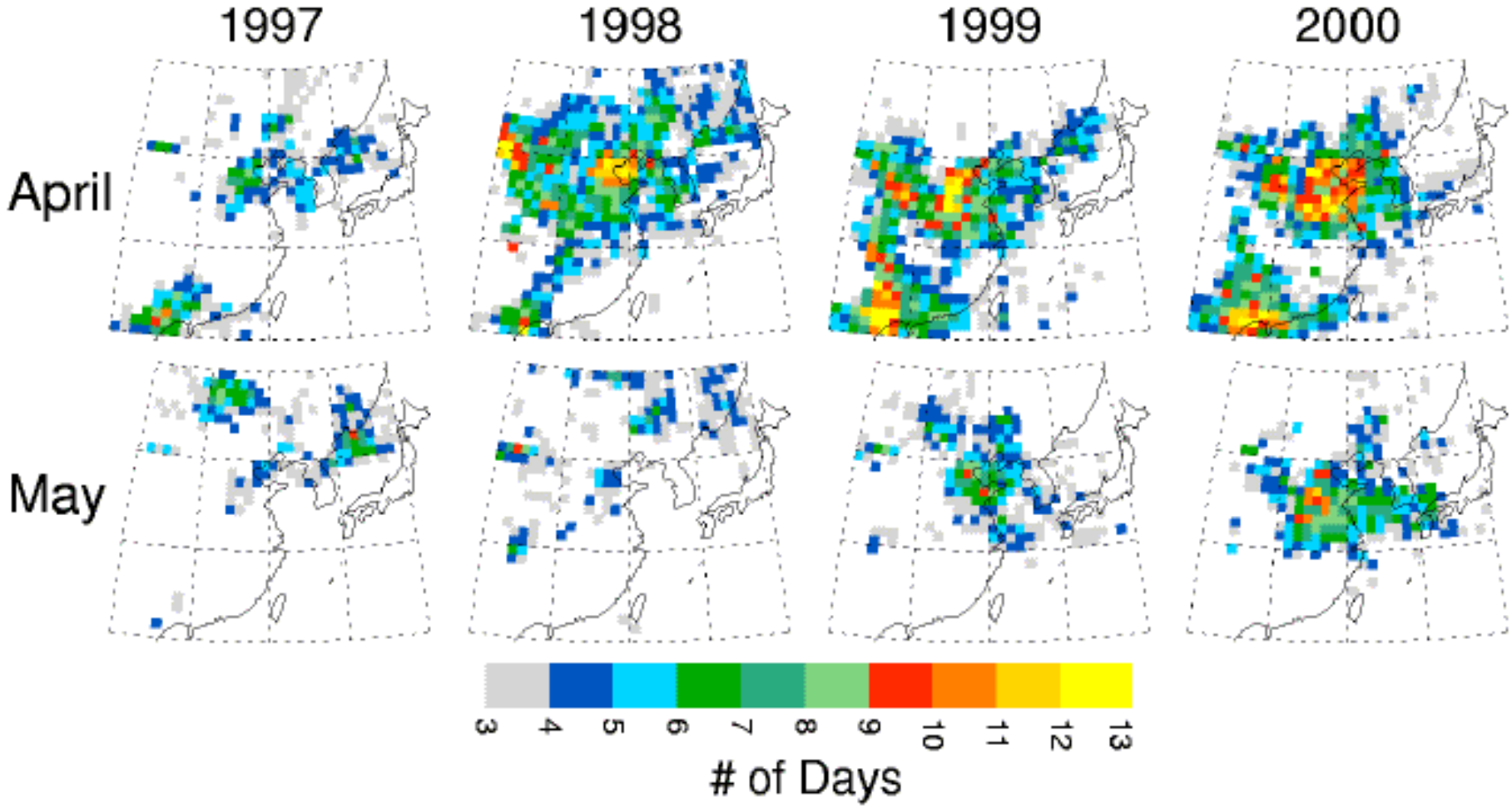
Kosa: 2000 Events





On 7 April 2000 SeaWiFS observed (left), in true color with Rayleigh scattering removed, the most powerful dust storm in 10 years over this region, (center) residents of Beijing ran for shelter as gusts of up to 44 mph scoured the streets and darkened the skies (CNN), and (right) this reminds Beijing residents of the fear in a science fiction movie "The Vanished City" (Chinese news paper in US).

Spatial & Temporal Trends

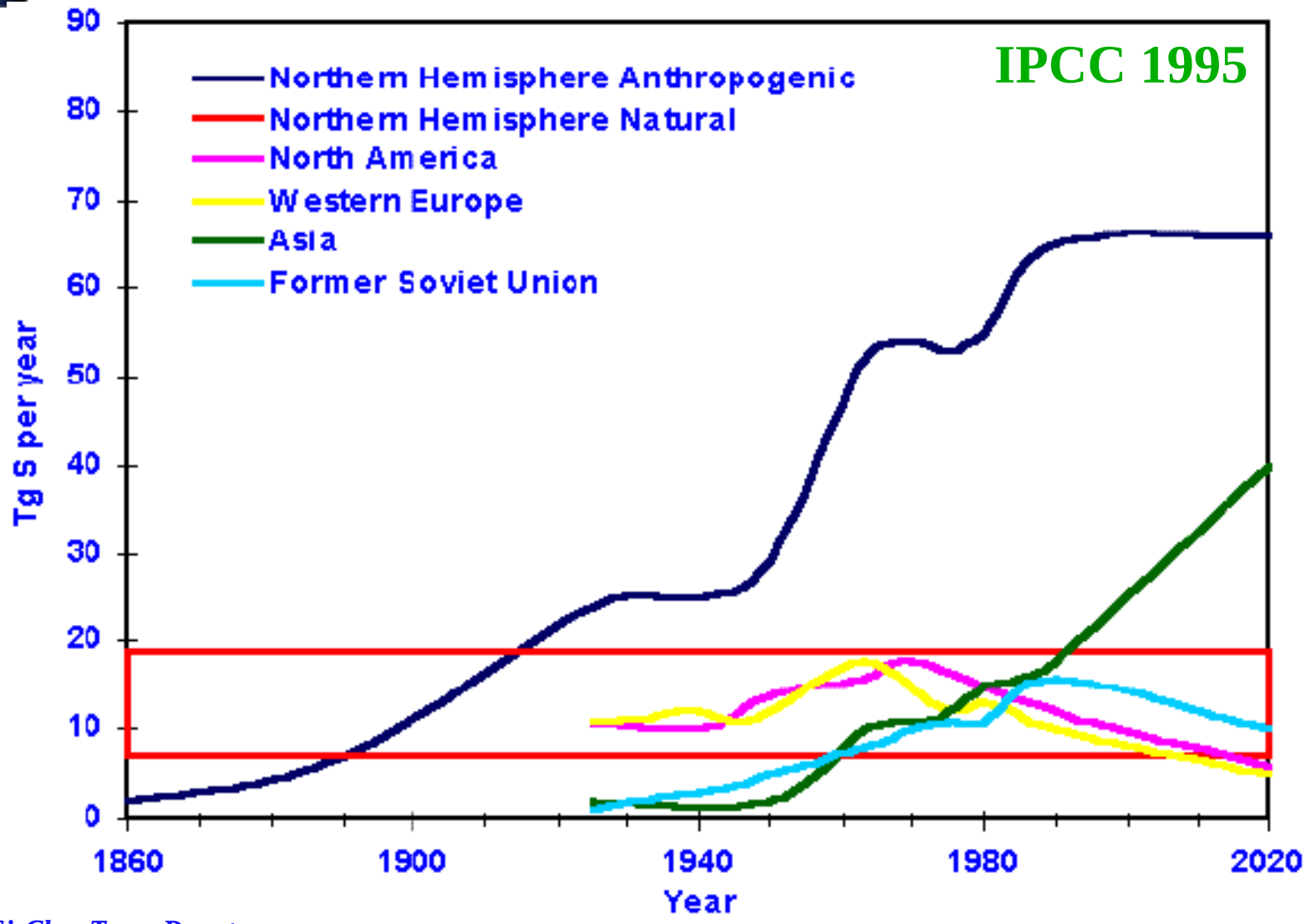


Monthly statistics of aerosol-covered areas (1° x 1.25°) observed by TOMS

ACE-Asia: Background

"*Economic expansion* in many Asian countries is unavoidably accompanied by increases in coal & biomass burning, industrial pollution, and land cover/use change (*natural* and *anthropogenic* aerosols). ..."

N. Hemisphere Sulfur Emissions



ACE Heritage: IGAC

Projects coordinated by International Global Atmospheric Chemistry:

- ***ACE-1:*** **Aerosol Characterization Experiment-1 (remote marine aerosols in Southern Hemisphere, Nov.-Dec. 1995).**
- ***TARFOX:*** **Tropospheric Aerosol Radiative Forcing Observational eXperiment (anthropogenic aerosols off east coast of the North America to mid-Atlantic Ocean, July 1996).**
- ***ACE-2:*** **Aerosol Characterization Experiment-2 (anthropogenic aerosols outflow from the European continent and desert dust from the African continent into the North Atlantic Ocean, June-July 1997).**

Societal Concerns

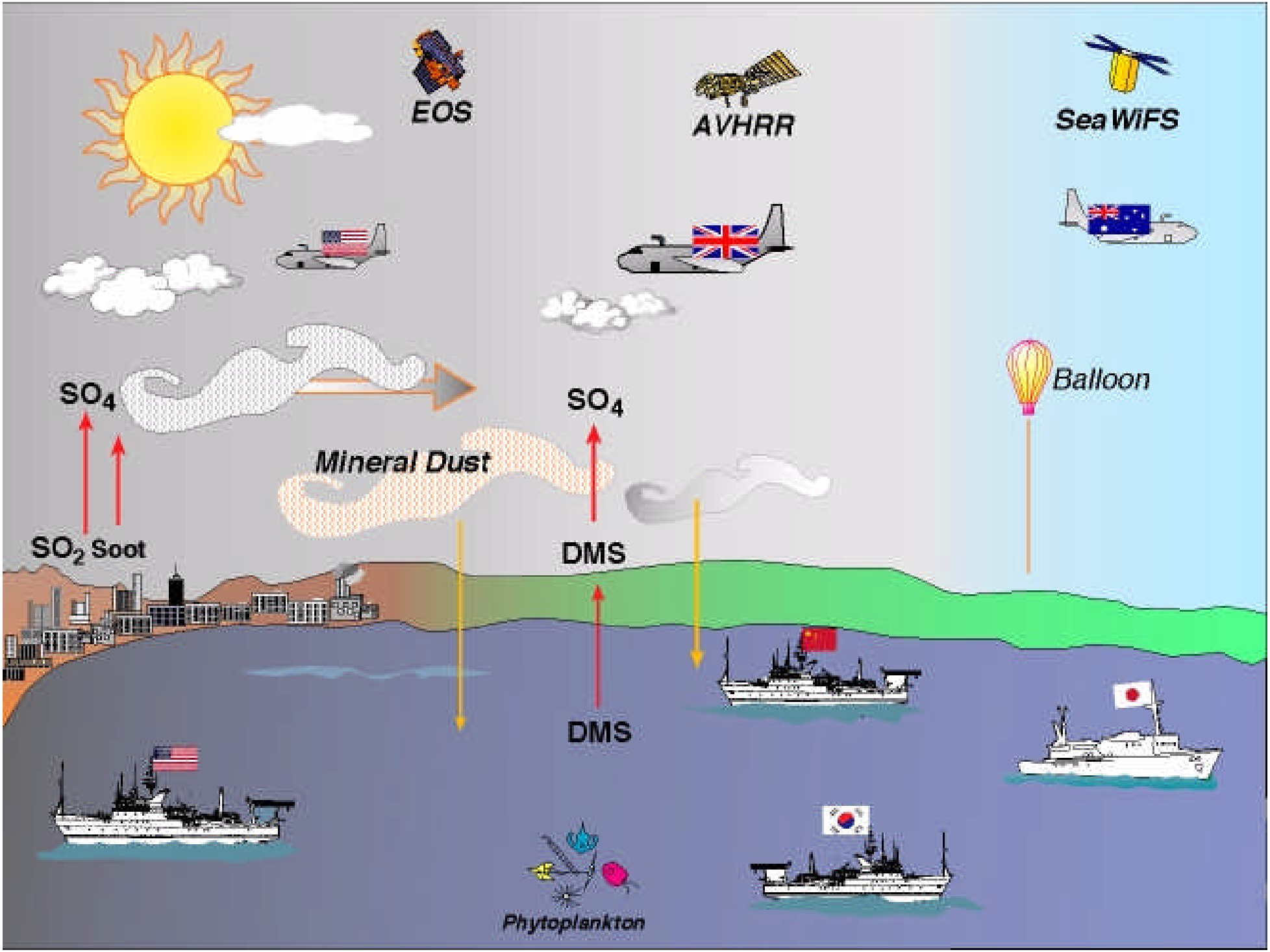
- *Might the distribution of rainfall from the Asian monsoon change enough to reduce agricultural output in some regions?*
- *Will fisheries be impacted by changes in the deposition of trace metals from acidified dust and industrial emissions?*
- *Will the extremes of Asian climate change because of changes in the radiative forcing by sulfates, soot, and dust?*
- *Will there be adverse health effects from increases in acidic particles downwind of major sources?*
- *How will kosa (severe events that blanket East Asia with yellow desert dust) be altered?*

ACE-Asia: Objectives

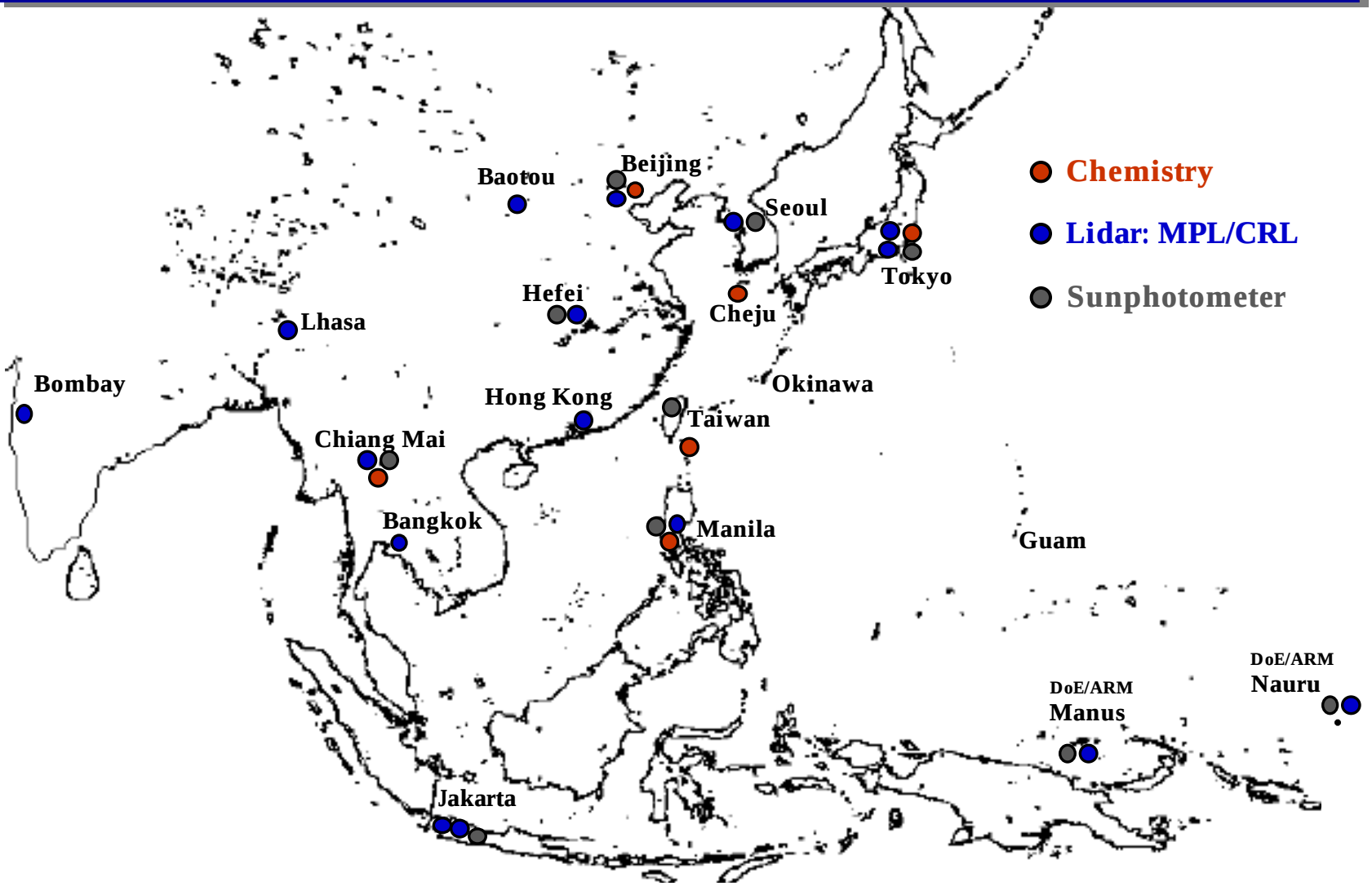
- *Determine the physical, chemical, and radiative properties of the major aerosol types in the Eastern Asia and Northwest Pacific regions and investigate the relationships among them;*
- *Quantify the physical and chemical processes controlling the evolution of the major aerosol types and in particular of their physical, chemical and radiative properties; and*
- *Develop procedures to extrapolate aerosol properties and processes from local to regional and global scales, and assess the regional direct and indirect radiative forcing by aerosols in the Eastern Asia and Northwest Pacific regions.*

Experimental Approach

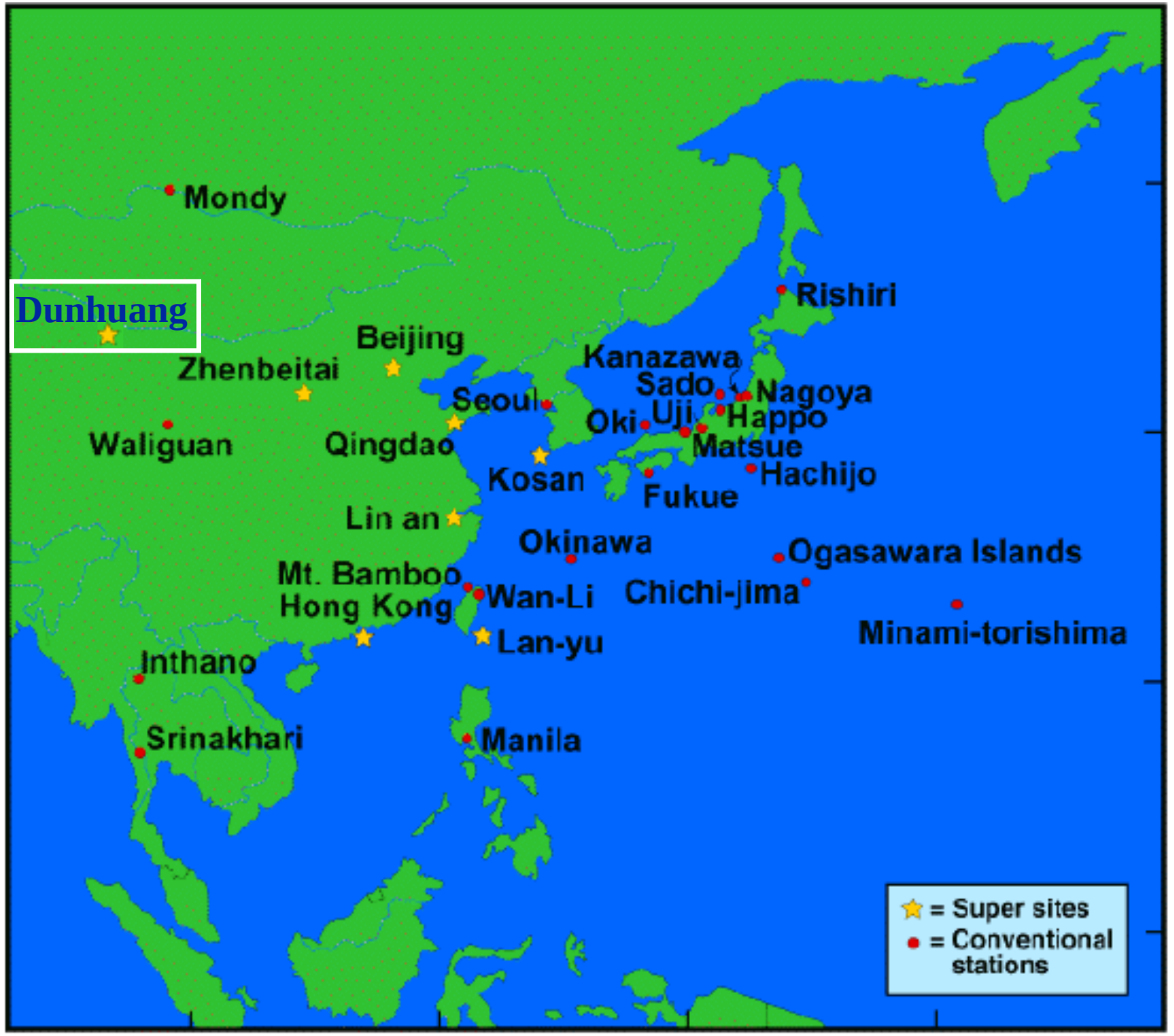
- *Aerosol properties and optical depth will be measured at a network of ground stations and during ship cruises and aircraft flights in IOPs;*
- *The direct radiative effect of aerosol particles in the ACE-Asia study area will be quantified in column closure experiments; and*
- *The effect of clouds on aerosol properties and the effect of aerosols on cloud properties (indirect effect) will be quantified in focused process studies.*


EOS
AVHRR
SeaWiFS
SO_4
SO_4
Balloon
Mineral Dust
SO_2 Soot
DMS
DMS
Phytoplankton

Asian Surface Measurement Network

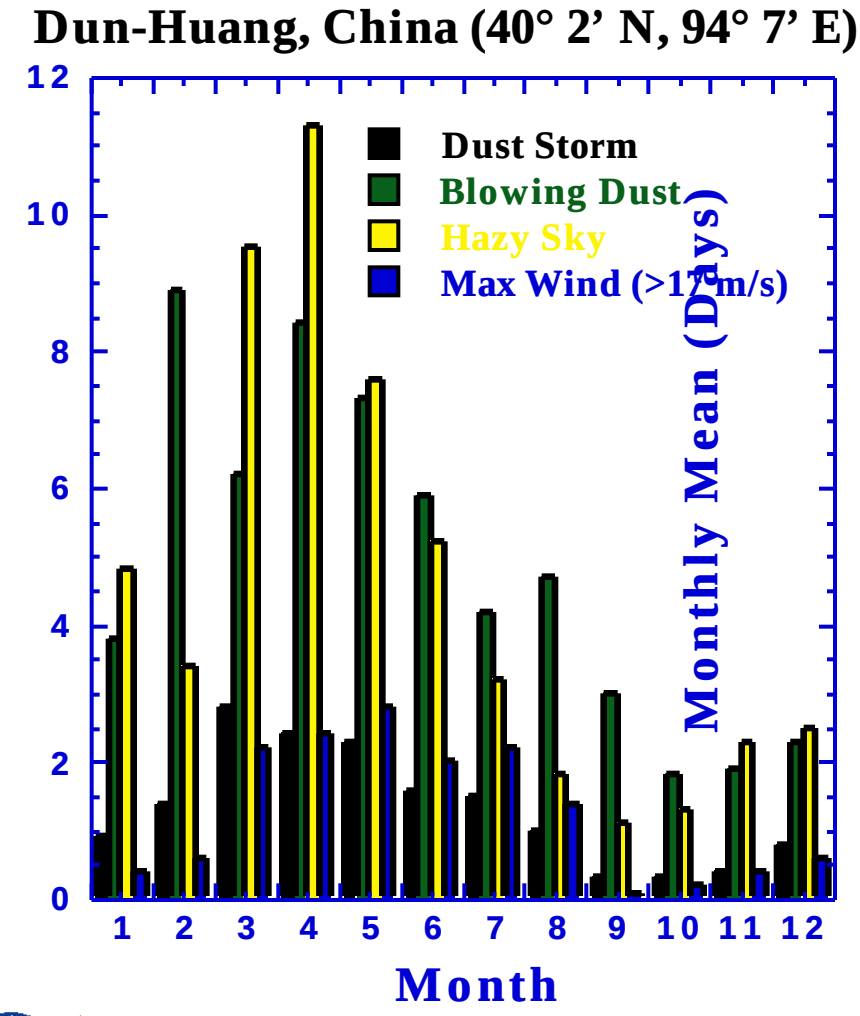


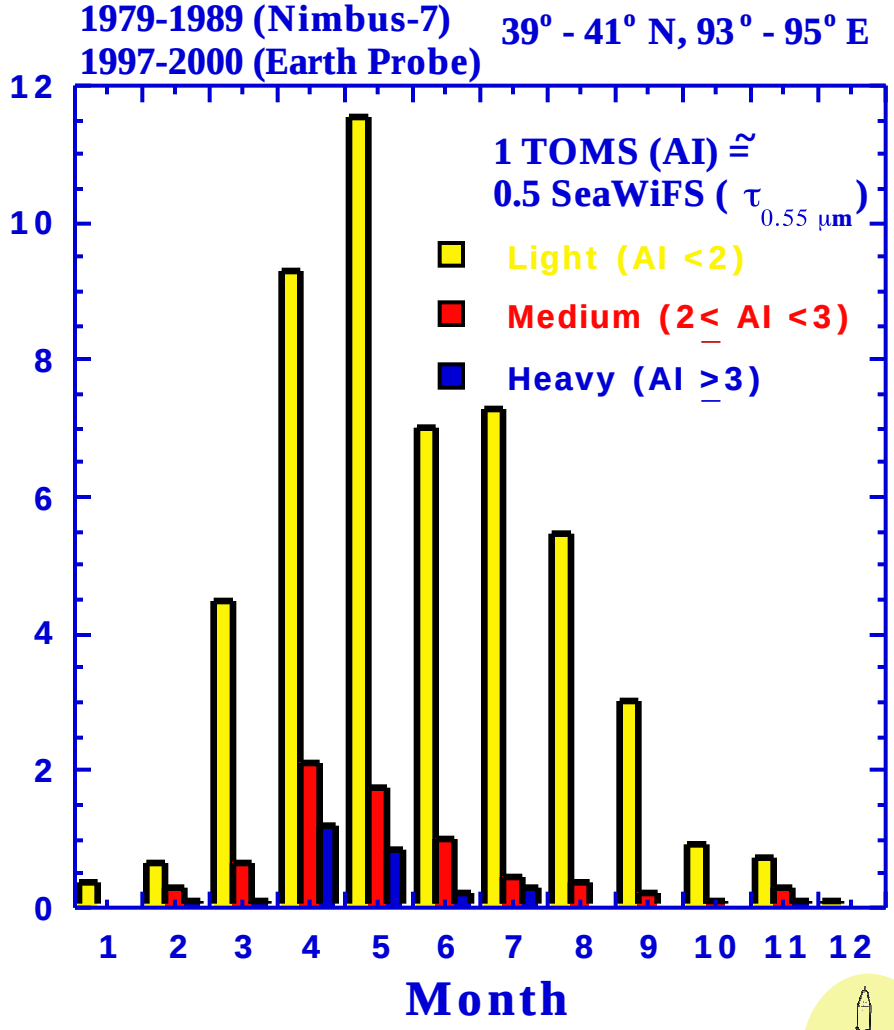
ACE-Asia Sites



1951-1980 Surface Observations

1979-2000 Satellite Observations

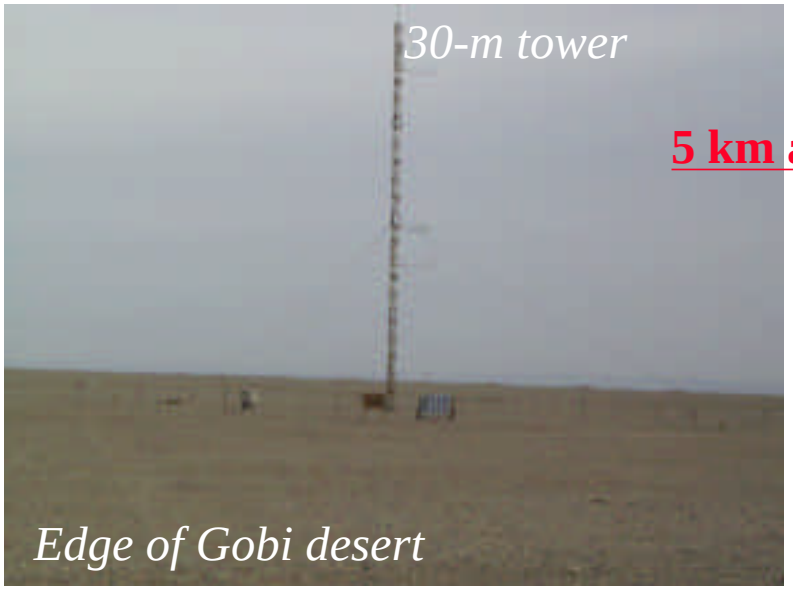




Monthly Mean Events

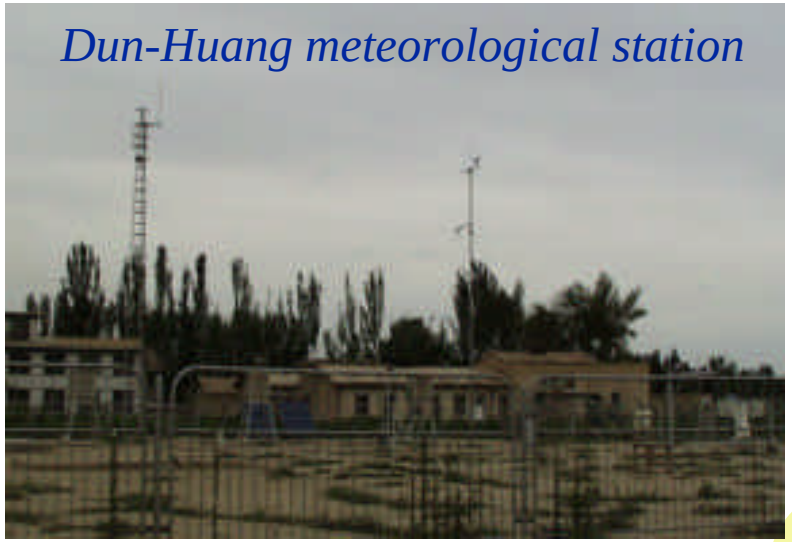
Si-Chee Tsay, Deputy
EOS/Terra Project Scientist

January 23, 2001
NASA/GSFC Code 913



5 km apart

Dun-Huang: ***the largest oasis in this region***



Proposed: Observations

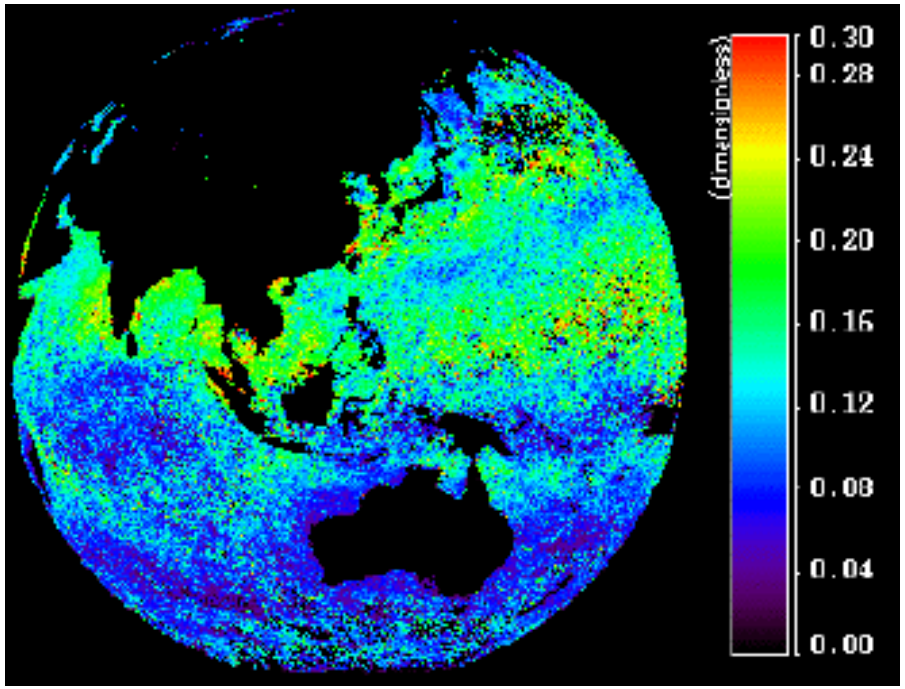
- *Acquire, process and analyze surface remote sensing measurements from SMART*
- *Provide and coordinate the use of near-real-time information from TOMS, SeaWiFS, and Terra satellites*
- *Intercompare aerosol retrievals from surface (SMART) and satellite (TOMS & SeaWiFS) remote sensing*
- *Evaluate dust transport models using satellite data*
- *Determine aerosol direct radiative forcing at the top of atmosphere from Terra MODIS and CERES*

SMART: Surface Measurements for Atmospheric Radiative Transfer

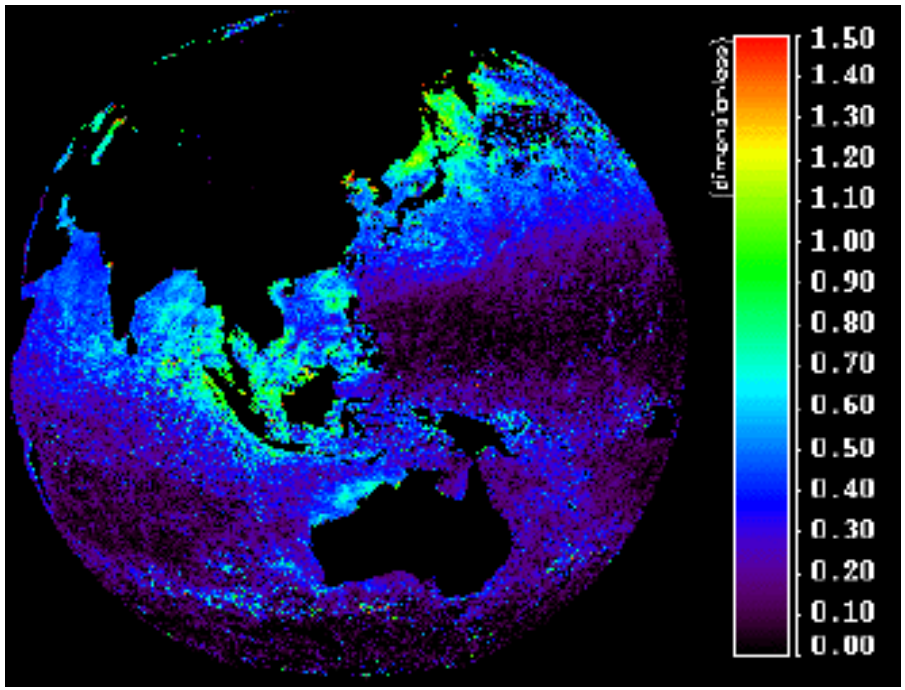
http://particle.gsfc.nasa.gov/smart

Satellite Observation/retrieval

SeaWiFS retrievals for April 1998



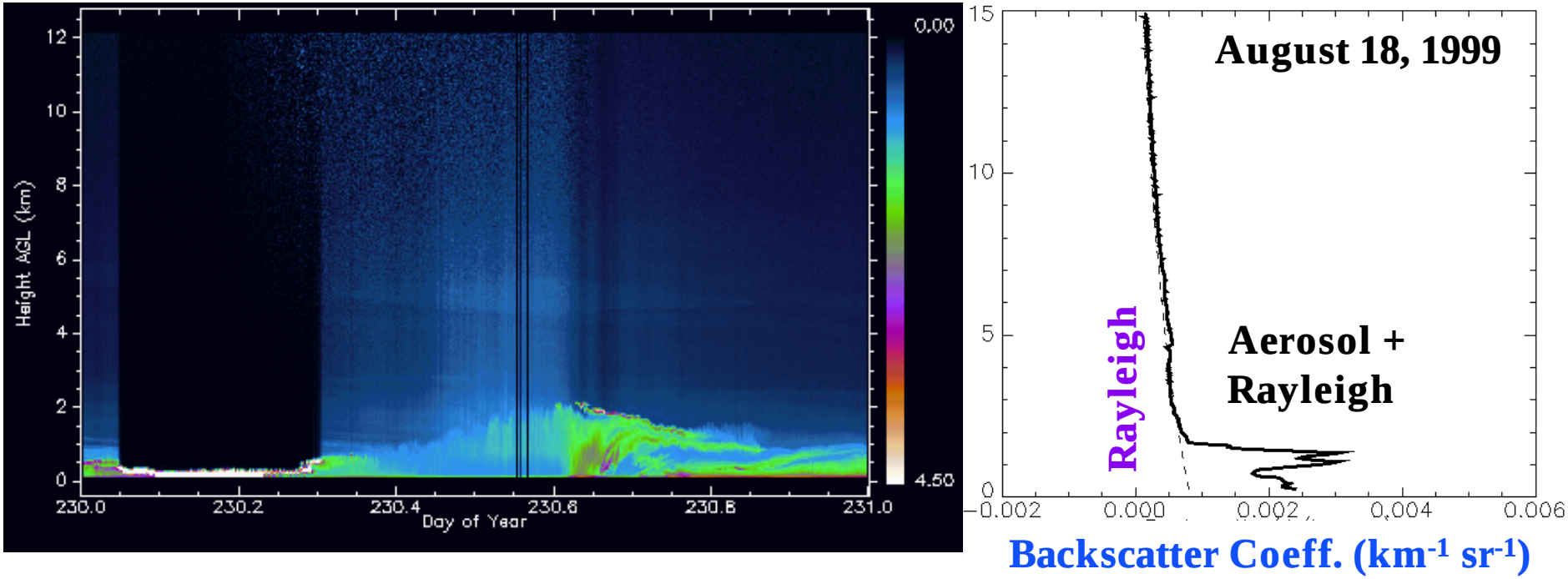
Aerosol Optical Thickness at 865 nm



Angstrom Exponent

Lidar: Vertical Distribution

Aerosol Re-circulation and Rainfall Experiment

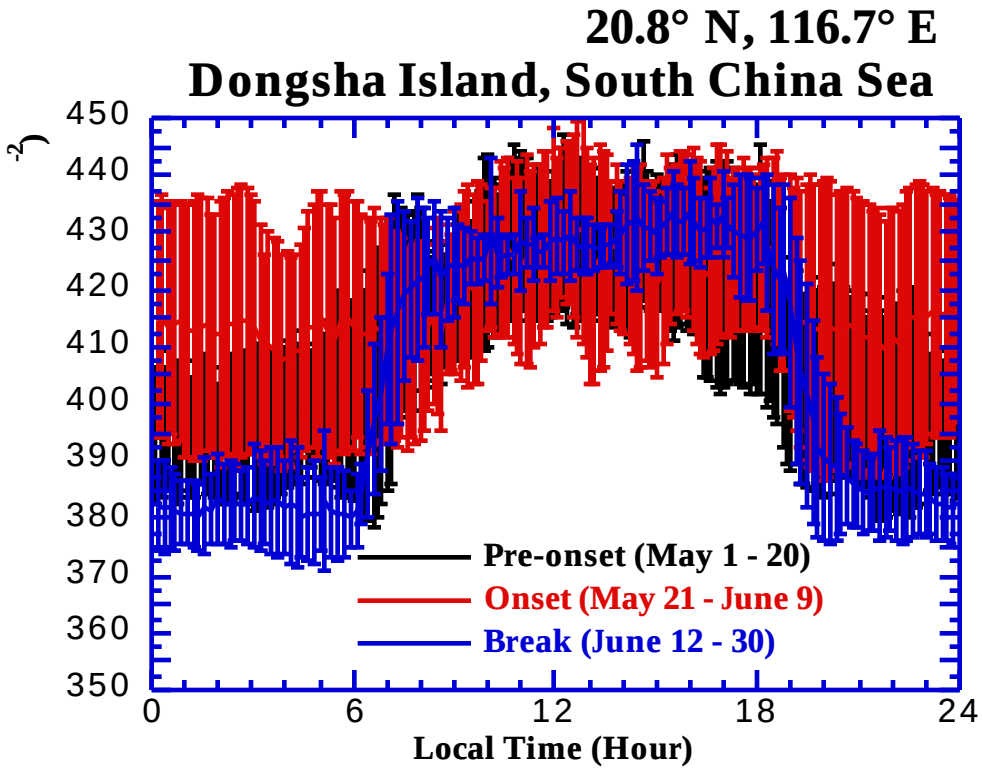


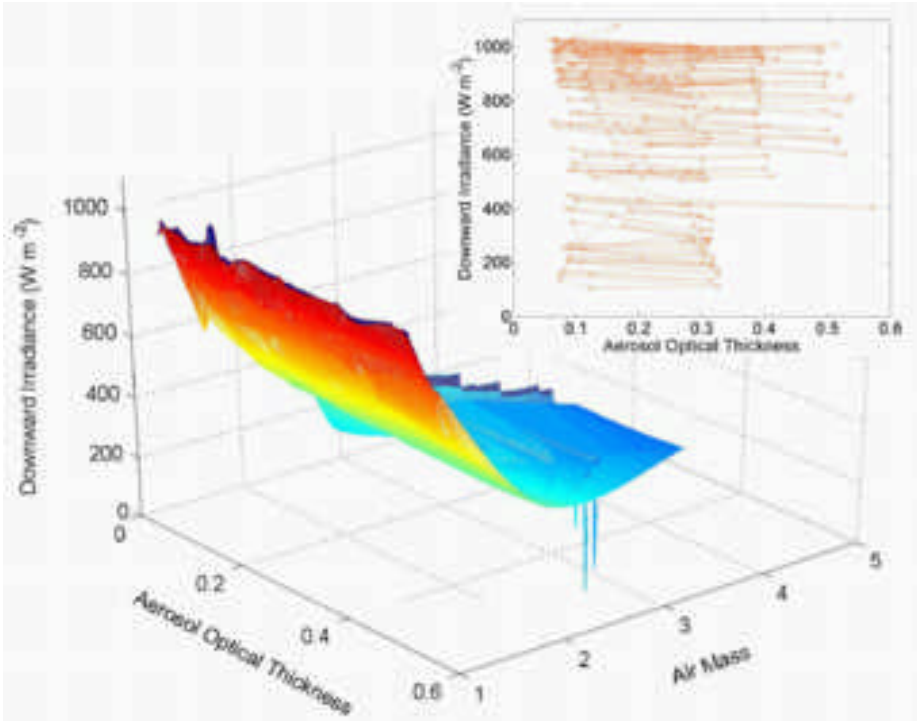
Skukuza, South Africa

Cloud Thermal Effects (SCSMEX)

Aerosol Radiative Forcing (PRIDE):

$\Delta F/\Delta\tau \sim -95\ W\ m^{-2}$





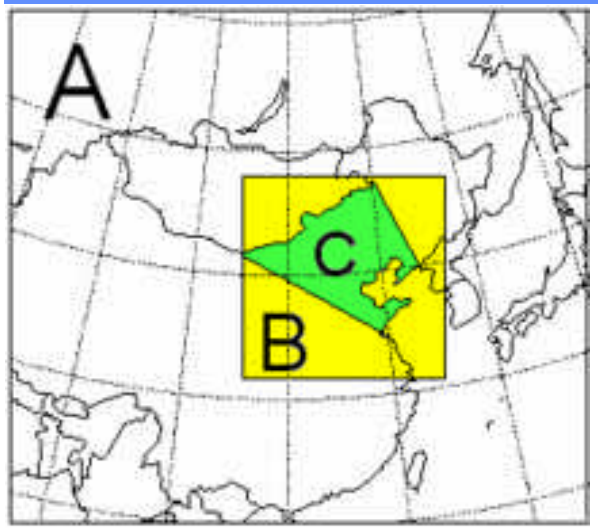
Diurnal variation of thermal radiation at surface

Puerto Rico (18.3° N, 65.7° W)

Proposed: Simulations

- *Advance the understanding of climate and hydrology in East Asia in spring using Single Column and Regional Climate models*
- *Investigate the effects of clouds, dusts and aerosols on radiation and regional climate*
- *Explore precursors of dust storm and transport of dust*
- *Evaluate the effect of land cover change on regional climate and dust storms*

Purdue Regional Model



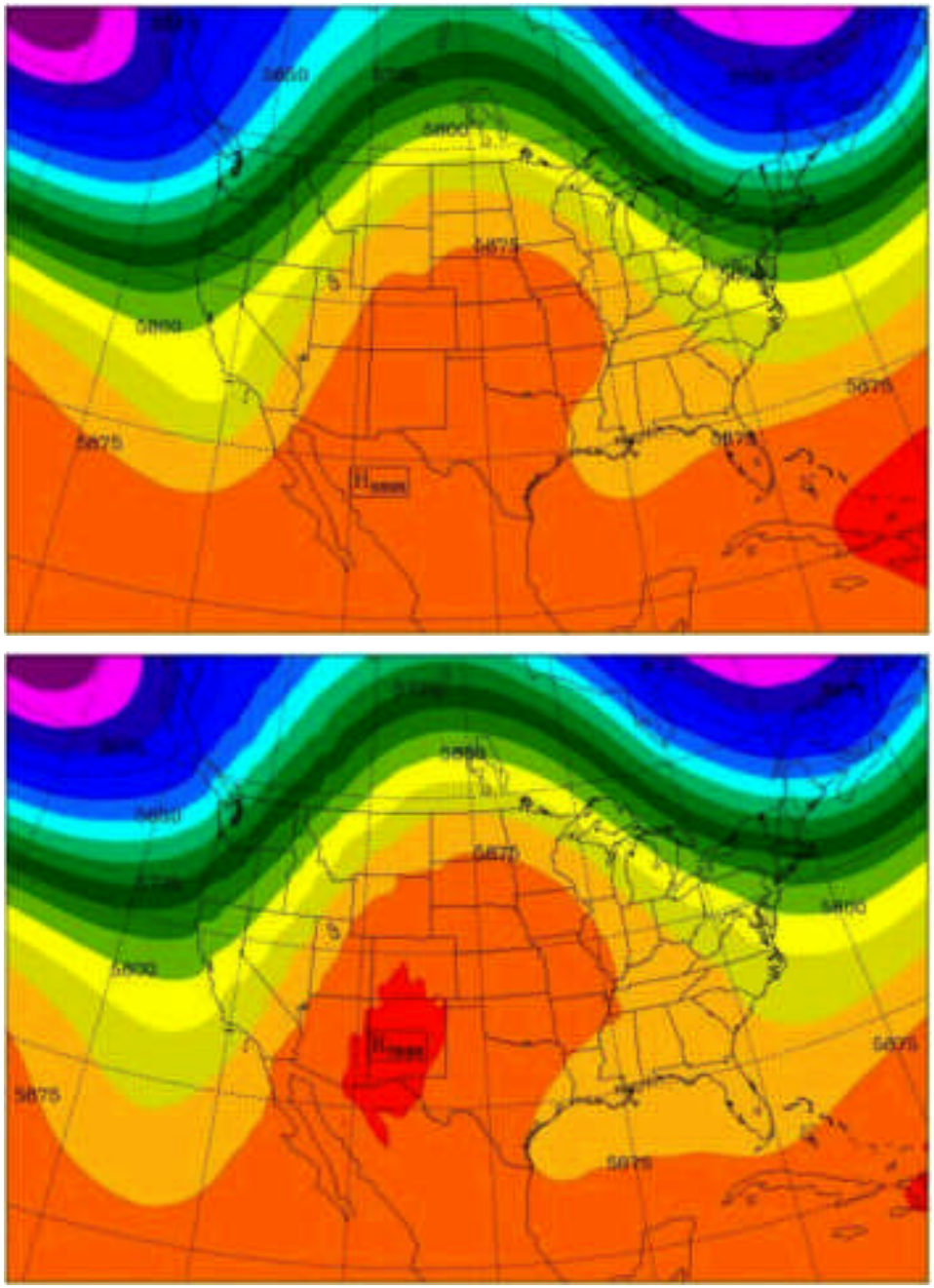
Domain ***A*** (Δx=60 km), ***B*** (Δx=20 km), and area ***C*** inside ***B*** for sensitivity test of soil and vegetation.

- ***Prognostic equations for wind, equivalent ice potential temperature, surface pressure, turbulent kinetic energy, all phases of water***
- ***Radiation and cumulus parameterizations***
- ***Coupled atmosphere-land-vegetation model***
- ***Second-order turbulence-pollution model***

Severe Drought in US: June 1988

ECMWF Monthly Mean

PRM Simulation



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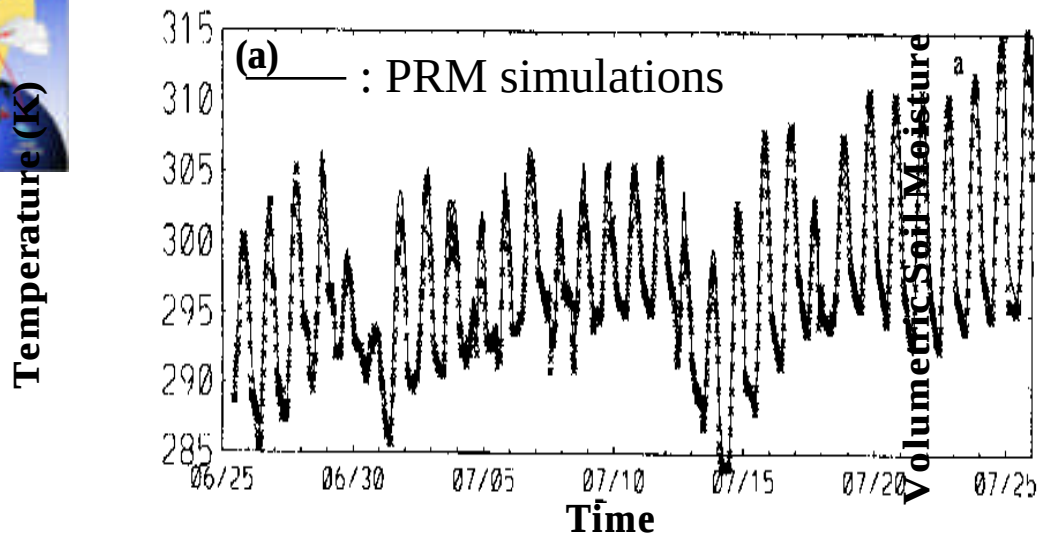
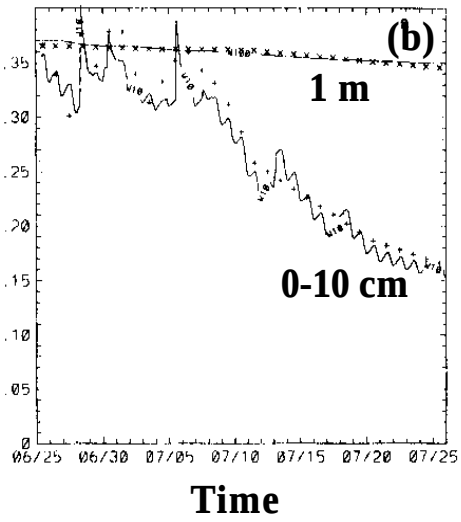
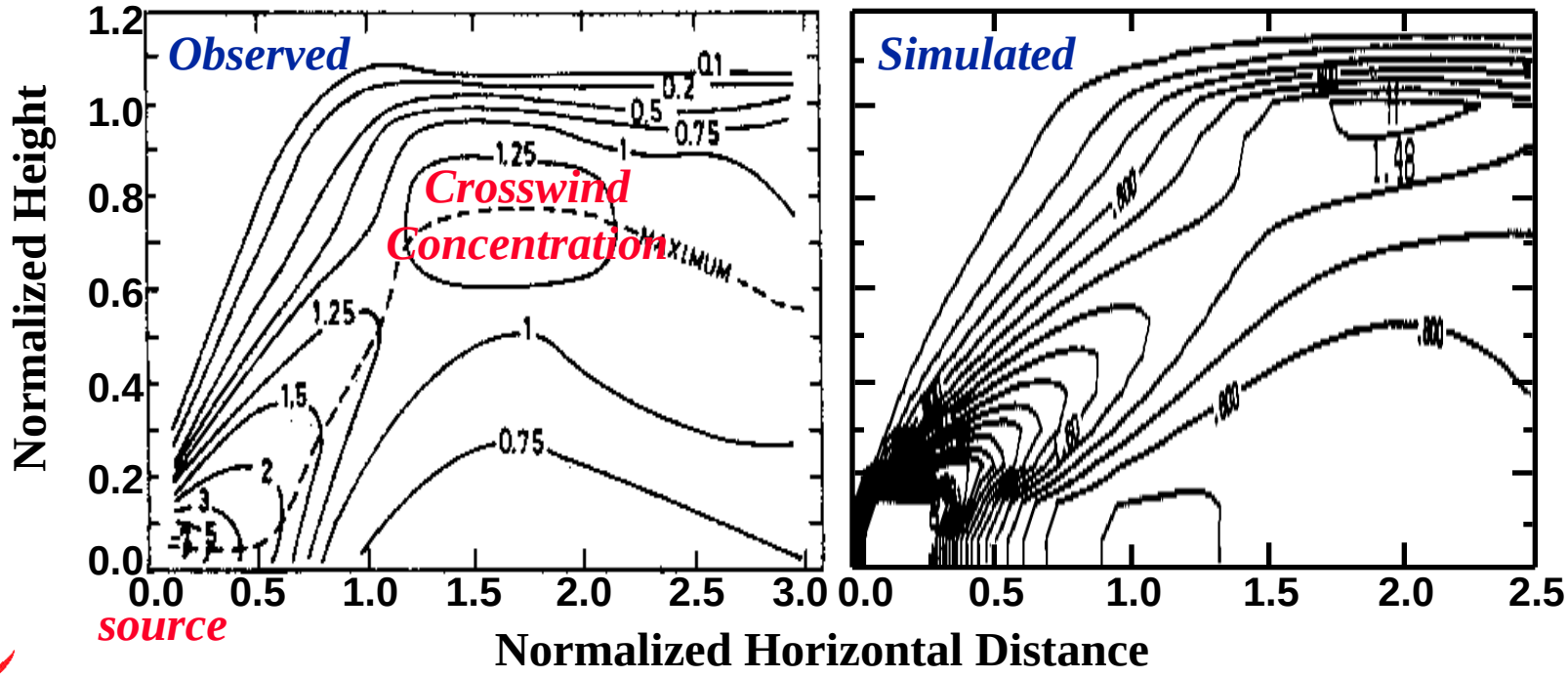
x: monthly observation during FIFE campaign (25 June - 25 July 1987)







Summary

- ***Work Hard*** **…**

  sub-freezing at desert …

- ***Have Fun*** **…**

  Dunhuang is the gateway of ancient “Silk Road” …

Climatic Effects of Tropospheric Aerosol